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ABSTRACT

This unit of instruction presents an individualized mini-course in electricity and magnetism. The course is geared for college-preparatory high school students. A textbook and film bibliography, performance objectives, suggested conditions for completing objectives, a course outline, laboratory activities and suggested resources for the teacher are contained in this module. (JMP)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

THEORY OF ELECTRICITY AND MAGNETISM

5318.06

SCIENCE

(Experimental)

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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Written by Paul E. Jindra
for the
DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida
1972

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THEORY OF ELECTRICITY AND MAGNETISM

COURSE DESCRIPTION

The Theory of Electricity and Magnetism is a course in classical electricity and magnetism at the college-preparatory high school level. The material covered spans the field from elementary observations on static electricity to the work of Maxwell.

The course will furnish the student with the background information and manipulative techniques necessary for further physics study, especially in Modern Physics.

ENROLLMENT GUIDELINES

This course is designed for the student with skills obtained in Kinematics, Dynamics I, Light Theory and Algebra. Suggested prerequisities are Advanced Algebra and Geometry. A suggested corequisite is Trigonometry.

TEXTBOOKS

1. Genzer and Younger. Physics. Morristown, New Jersey: Silver Burdett Company, 1969.

2. Miller, Dillon, and Smith. Concepts in Physics. New York: Harcourt, Brace, Jovanovich, 1969.

3. Physical Science Study Committee. Physics, 2nd ed. Boston: D. C. Heath and Company, 1965.

* 4. Rutherford, et al. The Project Physics Course: 4 Light and Electromagnetism. New York: Holt, Rinehart and Winston, Inc., 1968.

5. Williams, et al. Modern Physics, rev. New York: Holt, Rinehart and Winston, Inc., 1968.

* The Authorized Interim Version, 1968-69 (chapters 14, 15, 16) was used in the preparation of this course.

PERFORMANCE OBJECTIVES

The student will:

1. Survey the ancient history of electrostatic and magnetostatic observations.

2. Observe some of the elementary electrostatic experiments, including electrostatic induction.

3. Discuss critically the postulation of electric charge as an explanation for electrostatic effects.

4. Describe the Coulomb-Cavendish electrostatic force law experiment.

5. Discern the quantum nature of electric charge and recognize the common unit of charge by observing or performing the Millikan oil drop experiment.

6. Cite evidence for the conservation of electric charge.

7. Observe the demonstration of electrostatic "field patterns".

8. Define the electric field.

9. Define electric potential difference (voltage) between two points.

10. Define electric current.

11. Distinguish between steady (DC) and non-steady current.

12. Note the graphical relation between current and voltage for various materials and states.

13. Define an ohmic material as one in which current is directly proportional to applied voltage.

14. Examine the laws of elementary electrical circuits, including power dissipation.

15. Review the history of magnetostatic effects up to the time of Gilbert.

16. Observe the demonstration of magnetostatic field patterns (as e.g. via iron filings)

PERFORMANCE OBJECTIVES (Continued)

17. Describe Oersted's discovery of a connection between electricity and magnetism.

18. Describe Ampere's discovery that currents exert forces on other currents in wires.

19. Write the relation between the magnetic field, the electric charge, the velocity of the charge, and the magnetic force acting on the charge, including directional properties.

20. Repeat or observe the Faraday electromagnetic induction experiment.

21. State Faraday's Law of electromagnetic induction.

22. Examine the application of Faraday's Law to devices such as electric generators and voltage/current transformers.

23. Note Faraday's discovery of an interrelation between light and electromagnetism in the Faraday Rotation of the plane of light polarization in matter in a magnetic field.

24. Discern the requirement for Maxwell's proposal of a displacement current.

25. Distinguish between a conduction current and a displacement current.

26. State Maxwell's reformulation of Faraday's Law.

27. State Maxwell's additional law for time-varying electric fields.

28. Infer electromagnetic waves from Maxwell's Laws.

29. Note Hertz's discovery of Maxwellian waves.

30 Examine the range of the spectrum of electromagnetic waves

31. Discuss critically the search for an extension of the Galilean Principle of Relativity to electromagnetic phenomena.

SUGGESTED CONDITIONS GIVEN FOR COMPLETING OBJECTIVES

T - text (listed for special emphasis only)
E - laboratory experiment
F - film
L - lecture, discussion
D - demonstration

1. T, L
2. D, E
3. L
4. T, L, F
5. D, F
6. T
7. D
8. L, F
9. L, F
10. L, F
11. L
12. T
13. L, F
14. T, E, F
15. T, L
16. D
17. T, L, E, F
18. T, L, E, F
19. T, L, F
20. D, F
21. T
22. T, E
23. L
24. L, T
25. T, L
26. T, L
27. T, L
28. L, F
29. T
30. T, L
31. L

COURSE OUTLINE

I. Scope of Course

A. Background of electric and magnetic effects

B. Classical electricity and magnetism

1. Limitations

2. Non-quantum mechanical descriptions

II. Electrostatics

A. Experimental observations

B. Existence of electric charge

C. Coulomb experiment

D. The electric field

E. Electrostatic energy, potential

III. Charges in Motion

A. Steady currents

B. Electric circuit laws and components

IV. Electromagnetism

A. The magnetostatic field

B. Oersted/Ampere experiments

C. The magnetic vector force law

D Electromagnetic induction

1. Faraday induction experiment

2. Practical applications and Lenz's Law

E. Electromagnetic waves

1. Faraday Rotation experiment

2. Maxwell's relations

COURSE OUTLINE (Continued)

a. Displacement current
b. Maxwell's Field Laws
c. Prediction of electromagnetic waves

3. Hertz's experiment

5. Special relativity

PROCEDURES

The fundamental ideas to be presented in the course are:

1. existence of electric charge and current

2. relation between electric current and the magnetic field

3. electromagnetic induction

4. electromagnetic waves.

Hence the four areas of crucial objectives which are to be stressed are:

1. 3, 10 (and a discussion of Volta's battery)

2. 17

3. 20, 21

4. 23, 28, 29

An individual course is to be designed around these key objectives, the completion of which is required, with the emphasis on the remaining supportive objectives at the discretion of the teacher.

LABORATORY ACTIVITIES (Continued)

36. Inductance in A-C Circuits (p. 122)
37. Series Resonance (p. 124)
38. Thermionic Emission (p. 126)
39. Diode Characteristics (p. 128)
40. Triode Characteristics (p. 130)
41. Voltage Amplification (p. 133)

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER

1. Coulomb Force Constant
   AV# 1-30301, 34', B/W

2. Coulomb's Law
   AV# 1-30298, 28', B/V

3. Counting Electrical Charges in Motion
   AV# 1-10755, 20', B/W

4. Electric Fields
   AV# 1-30271, 24', B/W

5. Electric Lines of Force
   AV# 1-01907, 7', B/W

6. Electrical Potential Energy and Potential Difference (Part I)
   AV# 1-30308, 30', B/W

7. Electrical Potential Energy and Potential Difference (Part II)
   AV# 1-30311, 24', B/W

8. Electromagnetic Waves
   AV# 1-30294, 30', B/W

9. Electrons in a Uniform Magnetic Field
   AV# 1-01915, 10', B/W

10. Elementary Charges and the Transfer of Kinetic Energy
    AV# 1-30304, 25', B/W

11. EMF
    AV# 1-10759, 19', B/W

FILMS AVAILABLE FROM DADE COUNTY AUDIOVISUAL CENTER (Continued)

12. Magnet Laboratory, A.
AV# 1-10772, 20', B/W

13. Mass of the Electron
AV# 1-10763, 18', B/W

14. Millikan Experiment
AV# 1-30314, 30', B/W

REPORTS

Famous men:

1. Gilbert
2. Franklin
3. Coulomb
4. Cavendish
5. Volta
6. Oersted
7. Ampere
8. Gauss
9. Faraday
10. Henry
11. Maxwell
12. Hertz
13. Lebedev

Research topic (virtually an unbounded list, typical of which would be):

14. Solar Wind
15. Millikan Experiment
16. Kirchoff's Circuit Laws
17. The Transformer
18. Electric Generators
19. Ampere's Circuital Law
20. The Faraday Rotation Experiment
21. Electromagnetic Spectrum Applications
22. Light Pressure

RESOURCES FOR TEACHERS

Reference text for further reading.

Halliday, David and Resnick, Robert. Physics. New York: John Wiley and Sons, Inc., 1966. Chapters 26 through 40.

Numerous demonstration examples prefered by the teacher may be used, e.g. those found in

Physical Science Study Committee. Physics Teacher's Resource Book and Guide, Part IV. Boston: D. C. Heath and Company, 1966.

MASTER SHEET--THEORY OF ELECTRICITY AND MAGNETISM

Objectives	Student Text References	Labs	Films	Reports	Teacher's References
1	#4. pp. 35-38 #3. p. 44			1	p. 647
2	#3. pp. 465-472	1,2		2	
3	#4. pp. 39-41 #3. p. 465				p. 648
4	#4. p. 39 #3. pp. 483-486	3	1,2	3,4	p. 650
5	#4. pp. 52-[illegible] #3. pp. 490-497	5,6	14	15	p. 654
6	#3. p. 500				p. 65[illegible]
7	#4. pp. 50-51 #3. p. 489				p. 669
8	#4. p. 49 #3. p. 486	5,8	4		p. 66[illegible]
9	#4. pp. 57-59 #3. pp. 5[illegible]0-521		6,7		p. 708
10	#4. pp. 56-57 #3. pp. 512-513		3		
11					p. 779
12	#3. pp. 535-537				p. 779
13	#3. pp. 537		10		p. 778
14	#4. pp. 60-61 #3. pp. 530-531, 539-540		11	16	p. 792
15	#4. pp. 35-37 #3. p. 546				p. 814
16	#4. pp. 66-67 #3. p. 549				
17	#4. pp. 62-63 #3. p. [illegible]48	10 11	12	5,6	
18	#4. pp. 64-65	13	12	7,8	pp. 819,844
19	#4. pp. 65-69		9		p. 816
20	#4. pp. 79-82*		5	9,10	p. 870
21	#4. p. 81			17,18	p. 871
22	#4. pp. 86,95				p. 873

MASTER SHEET--THEORY OF ELECTRICITY AND MAGNETISM (continued)

Objectives	Student Text References	Labs	Films	Reports	Teacher's References
23	#4. p. 107			20	
24	#4. p. 109 #3. p. 584			11	p. 962
25	#4. p. 109			17	
26	#4. p. 111				p. 959
27	#4. pp. 110-111				p. 959
28	#4. p. 112*		8	13,22	pp. 959,98
29	#4. pp. 110-111			12	p. 986
30	#4. pp. 120-123 #3. pp. 585-590			21	p. 993
31	#4. pp. 130-131 #3. p. 588				p. 1003

*Highly recommended